The development of a screening aid for congenital dislocation of the hip

THE DEVELOPMENT OF A SCREENING AID FOR CONGENITAL DISLOCATION OF THE HIP

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Congenital Dislocation of the Hip, of C.D.H., is a condition that a child can be born with or develop shortly after birth. Although affecting only 2 per 1,000 live births in Northern Ireland, the psychological and financial advantages make an early diagnosis desirable. Screening for C.D.H., although supposedly widespread has met with limited success because of the subjective nature of the test and the need for experienced personnel.

This test procedure stresses the hips in order to test joint laxity, that is, the tendency to move in and out of joint. If a dislocation or subluxation occurs, a palpable transient vibration or "clunk" is produced. A higher frequency transient vibration may also be produced by a different phenomenon; "cavitation".

In this department, the transient vibrations have been detected using vibration sensors (accelerometers) and recorded on an F.M. tape recorder (1). The tape was then replayed and analysed on a spectrum analyser and micro-computer (2). This early system was used for a pilot study on an at risk group of 300 neonates and gave an indication of the amplitude and frequency of typical hip transient vibrations. The system although being flexable, was bulky, difficult to use, and prohibitively expensive. This paper describes a micro-computer based data logging system which captures, displays and analyses hip vibrations. The objectives of the screener were to reduce cost and complexity and to present data to an inexperienced operator allowing an objective diagnosis to be made.

The data logger, or C.D.H. screener, was based on an Apple IIe microcomputer equipped with an analogue to digital converter, 128 kbyte extended memory and a single disk drive. A simple 555 timer based clock was assembled to syncronise the A/D sampling. As before, the signals are detected by three light weight accelerometers, two placed anteriorly on the left and right iliac spines and one posteriorly on the sacrum (bony prominances around the child's pelvis). The signals are conditioned by an amplifier and active filters built in the department. The software was written entirely in 6502 machine code except for the BASIC start-up program which simply loads the machine code and look-up tables from the disk. The software operates in three phases.

Phase 1 captures the vibrations generated at the transducer sites as the hips are stressed. The A/D convertor samples each of the three accelerometers in turn at the clock rate of 4kHz. The sampled data is stored on the extended memory, which is configured in 8 banks of 16 kbytes. Each bank stores 4 kbytes from each transducer (1 second of information), 4 kbytes being left unused. Total sample time is thus eight seconds which is sufficient for the hip test. Sampling ends when the eight seconds have elapsed or if the operator presses a footswitch.

Phase 2 is entered automatically when sampling is complete. The three channel data are displayed graphically a page at a time. Movement through the data is controlled via custom keyboard by the operator or by a search feature which only displays a page if any of the vibration data has exceeded a preset trigger level. The amplitude and time scales can be halved, or doubled and any channel or channels deleted or redrawn by a one touch keyboard entry, in order to make signal identification easier. The two transient signals are easily differentiated from artefact because a vibration produced by one hip is repeated on the other two channels. Therefore a vibration at the left hip also appears on the channel for the right hip, but in antiphase and to a lesser extent on the sacral channel. To differentiate between the two transients, phase 3 of the software is executed.

The analysis phase calculates frequency and time comain parameters on the currently displayed data, after saving the data to disk. Left and right hand edges are used to window in on the transient of interest. The average value is calculated and removed for each channel, to reduce any d.c. offset present. The operator selects a channel for frequency analysis, usually the affected side. A 256 point fast Fourier Transform operates on the windowed data which is extended to 256 samples by adding zeros to the end of the signal. The window size, peak-peak amplitude, peak frequency and weighted mean frequency parameters are superimposed on the power spectra and sent to a dot matrix printer.

At present, a large clinical trial is underway to explore a correlation between signal parameters and clinical findings. The screener itself is simple to use and excluding software development, the material cost has been reduced to 20% of the tape recorder based system.

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REFERENCES

1 G.H.Cowie et al. Vibration emission in detecting congenital dislocation of the hip. Orthopaedic Review 13(1), 1984: 30-35.

2 W.G. Kernohan et al. Microcomputer Analysis of Joint vibration. 5, 1982: 287-296.